

§4. Observation of Radial Electric Field Transition in CHS Plasma

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Structural formation of the radial electric field in toroidal plasmas, such as tokamaks and stellarators, is a key physics issue associated with improved confinement modes, such as H-mode. It has been postulated that the origin of the L-H mode transition should be ascribed to a change in the structure of the radial electric field near the plasma edge. A nonlinear dependence of plasma confinement on radial electric field should cause a bifurcation into two quite different states of better and worse confinement.

For toroidal helical plasmas, an absolute value of radial electric field is intrinsically influential to the confinement, since the helical ripple induced transport and loss cone loss are sensitive to the structure of the radial electric field. Neoclassical analysis has already shown that toroidal helical plasmas bifurcate into two states and possess the possibility of the existence of a solitary wave in the radial electric field. This nonlinearity inherent in toroidal helical plasmas gives rise to dynamic and drastic behavior in the radial electric field. The formation mechanism of the radial electric field, therefore, is essentially governed by nonlinearity which is one of the main subjects of modern physics. Here we report the observation of transition of the radial electric field in CHS plasma, using a heavy ion beam probe.

In the core of the CHS plasma during a combined heating of ECH and NBI, we have observed a spontaneous transition in the radial electric field. The potential profile in the pure ECH heating phase shows to have a steep gradient change around $r/a=0.3-0.4$, which suggests momentum transport barrier. When neutral beam injection was applied on this ECH plasma, an abrupt drop and rise in potential by about a half of central electron temperature (~ 400 V) was observed in the core of the plasma. The momentum transport barrier is destroyed and recovered in much faster time scale than the energy

confinement time, that is, a few dozen or hundred microseconds. The fine temporal resolution of the HIBP allows to observe microsecond timescale changes of the electric field, and a detailed view of this transition is shown in Fig.1.

This observation can deduce the nonlinear relation between the radial electric field and radial current (E-J curve), as is shown in Fig.2. The radial current governing the time scale of the transition is estimated experimentally to be about $5A/m^2$. Moreover, the HIBP signals imply that this radial electric field change is accompanied by a local electron density change. Therefore, we have experimentally confirmed for the first time that the E-J curve in the toroidal helical plasma has nonlinear characteristics that allow bifurcation in the radial electric field. This observation gives new insight into the structural formation of radial electric fields in toroidal plasmas[1].

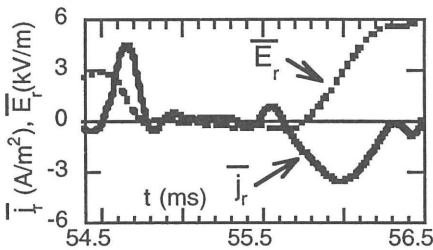


Fig. 1. Time evolution of radial electric field and radial current during the transition.

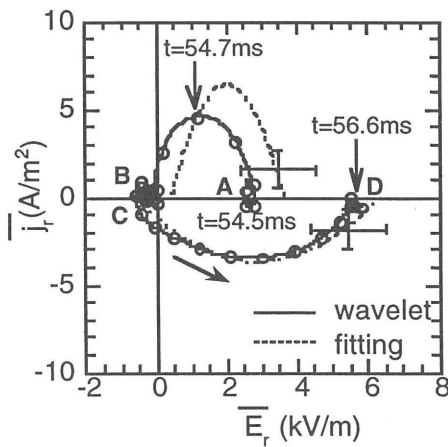


Fig.2. Experimental E-J curve to induce the observed transition of radial electric field.

References

1) A. Fujisawa et al., Phys. Rev. Lett. in press(1997).